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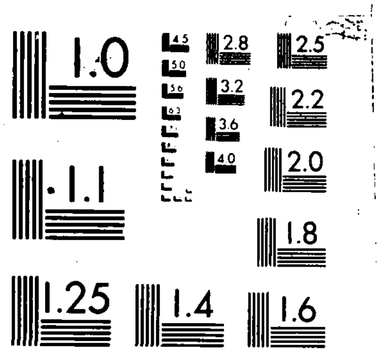

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IMPROVING THE QUALITY OF THE NAVY'S
MATERIAL HANDLING EQUIPMENT (MHE) FLEET
WITH SPECIAL EMPHASIS ON FORKLIFTS
AT NAVAL SUPPLY CENTERS

by

Robert J. Bump

December 1986

Thesis Advisor: Alan W. McMasters

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Reliable and readily available MHE is vital to all large scale military supply, maintenance and transportation operations. Therefore, the need to improve the quality of the Navy's MHE fleet cannot be over-emphasized. The current MHE inventory quality is poor and methods for improving this quality are essential. This thesis considers the Navy's forklift trucks because they comprise a large majority of the MHE fleet. A review of current MHE management policies, maintenance concept and plan, and replacement methodology is provided. Next, the current status of Navy forklifts at the eight Naval Supply Centers is analyzed to determine the average age and over-age of MHE, the compliance with DOD MHE replacement criteria, utilization rates and the extent of economically obsolete MHE. The results of this analysis showed that a significant percentage of these trucks are

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Improving the Quality of the Navy's Material Handling Equipment (MHE) Fleet With Special Emphasis on Forklifts at Naval Supply Centers

by

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Submitted in partial fulfillment of the requirements for the degree of

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ABSTRACT

Reliable and readily available MHE is vital to all large scale military supply, maintenance and transportation operations. Therefore, the need to improve the quality of the Navy's MHE fleet cannot be over-emphasized. The current MHE inventory quality is poor and methods for improving this quality are essential. This thesis considers the Navy's forklift trucks because they comprise a large majority of the MHE fleet. A review of current MHE management policies, maintenance concept and plan, and replacement methodology is provided. ~~Next,~~ the current status of Navy forklifts at the eight Naval Supply Centers is analyzed to determine the average age and over-age of MHE, the compliance with DOD MHE replacement criteria, utilization rates and the extent of economically obsolete MHE. The results of this analysis showed that a significant percentage of these trucks are over-aged and economically obsolete. The DOD criteria need to be replaced by the private sector approach for determining the economic life of MHE.

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TABLE OF ACRONYMS AND ABBREVIATIONS

APL	Allowance Parts List
BSM	Budget Simulation Model
CINCPACFLT	Commander in Chief, U.S. Pacific Fleet
CINCUSNAVEUR	Commander in Chief, U.S. Naval Forces, Europe
CNET	Chief of Naval Education and Training
CNO	Chief of Naval Operations
CONUS	Continental United States
CPA	Central Procurement Agency
DCSC	Defense Construction Supply Center
DGSC	Defense General Supply Center
DLA	Defense Logistics Agency
DLSIE	Defense Logistics Studies Information Exchange
DOD	Department of Defense
EES	Engineer and Equipment Specialist
FICP	Fleet Issue Control Point
GAO	General Accounting Office
HSC	Hardware Systems Command
ISEA	In-service Engineering Agency
LAPL	Lead Allowance Parts List
LPG	Liquified Propane Gas
MHE	Material Handling Equipment
MSC	Military Sealift Command
NAVAIR	Naval Air Systems Command

NAVSEA	Naval Sea Systems Command
NAVSUP	Naval Supply Systems Command
NSC	Naval Supply Center
NSCC	Naval Supply Center Charleston
NSCJ	Naval Supply Center Jacksonville
NSCN	Naval Supply Center Norfolk
NSCO	Naval Supply Center Oakland
NSCP	Naval Supply Center Pensacola
NSCPH	Naval Supply Center Pearl Harbor
NSCPS	Naval Supply Center Puget Sound
NSCSD	Naval Supply Center San Diego
NSD	Naval Supply Depot
NSN	National Stock Number
O&MN	Operation and Maintenance, Navy
OPN	Other Procurement, Navy
PM	Preventive Maintenance
POM	Program Objectives Memorandum
PTD	Provisioning Technical Documentation
PWC	Public Works Center
QDR	Quality Deficiency Report
RCP	Request for Contractual Procurement
SAMMS	Single Automated Material Management System
SM&R	Source Maintenance and Recoverability
SPCC	Ships Parts Control Center
SRO	Shop Repair Order
USN	United States Navy

I. INTRODUCTION

In 1979, the General Accounting Office (GAO) performed an audit with the purpose of determining if the Navy's Material Handling Equipment (MHE) costs could be reduced. After a thorough review of five different types of Navy activities, the GAO reported that:

> . . . elimination of unneeded material handling equipment, establishment of reasonable equipment allowances, and efficient use of needed equipment would save $5.3 million in future replacement costs at the five activities reviewed. If the Navy exercised effective management of material handling equipment at all its activities, future replacement costs and annual maintenance and repair costs could be reduced by tens of millions of dollars. [Ref. 1]

As a consequence of the GAO report, the Navy Ships Parts Control Center (SPCC) was directed by the Naval Supply Systems Command (NAVSUP) to effect corrective action of the deficiencies noted. SPCC promptly established, and/or revised, administrative policies and procedures governing the utilization, replacement, disposal, reporting requirements, and overall management of MHE. However, the quality of MHE continues to be in question.

A. PURPOSE

The purpose of this thesis is to analyze the current methods and policies of maintaining the Navy's fleet of MHE and to determine ways of improving these in order to increase the quality of that fleet. In particular, the analysis seeks to determine the extent to which utilization goals are being achieved, if the MHE fleet is economically obsolete, and if the Department of Defense (DOD) MHE replacement criteria are valid and followed at all Naval Supply Centers.

B. METHODOLOGY AND SCOPE

A field trip was taken to SPCC to familiarize the author with the current policies and procedures of MHE management. A field trip was also taken to NSC Oakland and NSC San Diego to acquaint the author with local MHE maintenance policies and procedures and the operating environment.

A review of pertinent literature included SPCC functional descriptions, management reports, point papers, and instructions, NAVSUP publications and instructions, and a search of the Defense Logistics Studies Information Exchange (DLSIE).

A statistical analysis was then conducted to determine average repair costs, average downtime, and average MHE age of Navy owned equipment. The data used in this analysis was obtained from SPCC's Ashore Activity Verification and Allowance Listing Report for fiscal year 1985 because it contained the most recent data. That report documented the MHE year of manufacture, acquisition cost, past year's repair cost, past year's downtime, accumulated repair cost, utilization percentage and accumulated hours of operations.

C. THESIS ORGANIZATION

Chapter II describes the Navy's current overall organizational structure and MHE management responsibilities, policies, and procedures. Chapter III discusses the Navy's MHE preventive maintenance system, non-standardization, and two methodologies for determining MHE replacement. Chapter IV presents the data generated from the Verification and Allowance Listing Report and analyzes this data to determine, per Supply Center, the average repair cost, the average downtime and the average age of forklift trucks. It also discusses the impact funding for procurement of forklifts has had on the over-age status of these trucks. Finally, this chapter discusses forklift under-utilization and compares the DOD and private sector MHE replacement concepts. Chapter V provides a summary and conclusions and recommendations.

II. BACKGROUND

The purpose of this chapter is to describe the organizational structure and management policies used to control and maintain Navy MHE. First, a brief overview of MHE is presented, followed by the organizational structure breakdown and, finally, a description of SPCC management responsibilities, policies and procedures.

A. OVERVIEW

Material Handling Equipment (MHE), for purposes of this study, is defined as

> . . . all self-propelled equipment normally used in storage and handling operations in and around warehouses, shipyards, industrial plants, airfields, magazines, depots, docks, terminals, and aboard ships. It includes all self-propelled materials handling equipment, such as, but not limited to, warehouse tractors, forklift trucks, platform trucks, pallet trucks, straddle carrying trucks, and mobile (warehouse) cranes. [Ref. 2:p. 2]

The Navy recognizes the need for a large dependable MHE fleet dispersed throughout the world in order to perform the physical handling requirements of its various activities. As of 1 June 1986, the Navy's MHE inventory stood at 14,874 items with a replacement value of $368 million [Ref. 3]. This inventory is composed of: (1) MHE at approximately 300 Naval Shore establishments; (2) MHE on approximately 250 ships including those of the Military Sealift Command (MSC); (3) rotatable pools of MHE located at Fleet Issue Control

Points (FICP's) at the Naval Supply Centers (NSC's) in Norfolk, Virginia, San Diego and Oakland, California and the Naval Supply Depots (NSD's) in Subic Bay, Philippines and Guam, to provide immediate replacements to fleet customers; and (4) prepositioned war reserve stocks at NSC Norfolk and Oakland [Ref. 4].

B. ORGANIZATIONAL STRUCTURE

MHE is managed by a highly centralized organizational structure that involves both Navy and Defense Logistics Agency (DLA) activities. Figure 2.1 displays the various defense activities involved in the management of MHE and their respective roles. To more fully understand the various interfaces between these activities, their responsibilities are described in the following subsections.

1. Naval Supply Systems Command (NAVSUP)

As the Navy's MHE program sponsor/functional manager, NAVSUP has several major responsibilities which are as follows:

(A) Provide SPCC formal guidance and direction in preparing the MHE budget based on Program Objectives Memorandum (POM) requirements received from the major claimants.

(B) Approve operation and general utilization standards that are developed and recommended by SPCC.

(C) Review and approve MHE life expectancy and repair limit criteria.

(D) Review all new MHE specifications and significant revisions to existing Navy MHE specifications for compliance with the Department of Defense (DOD) Standardization Program. This program requires all the

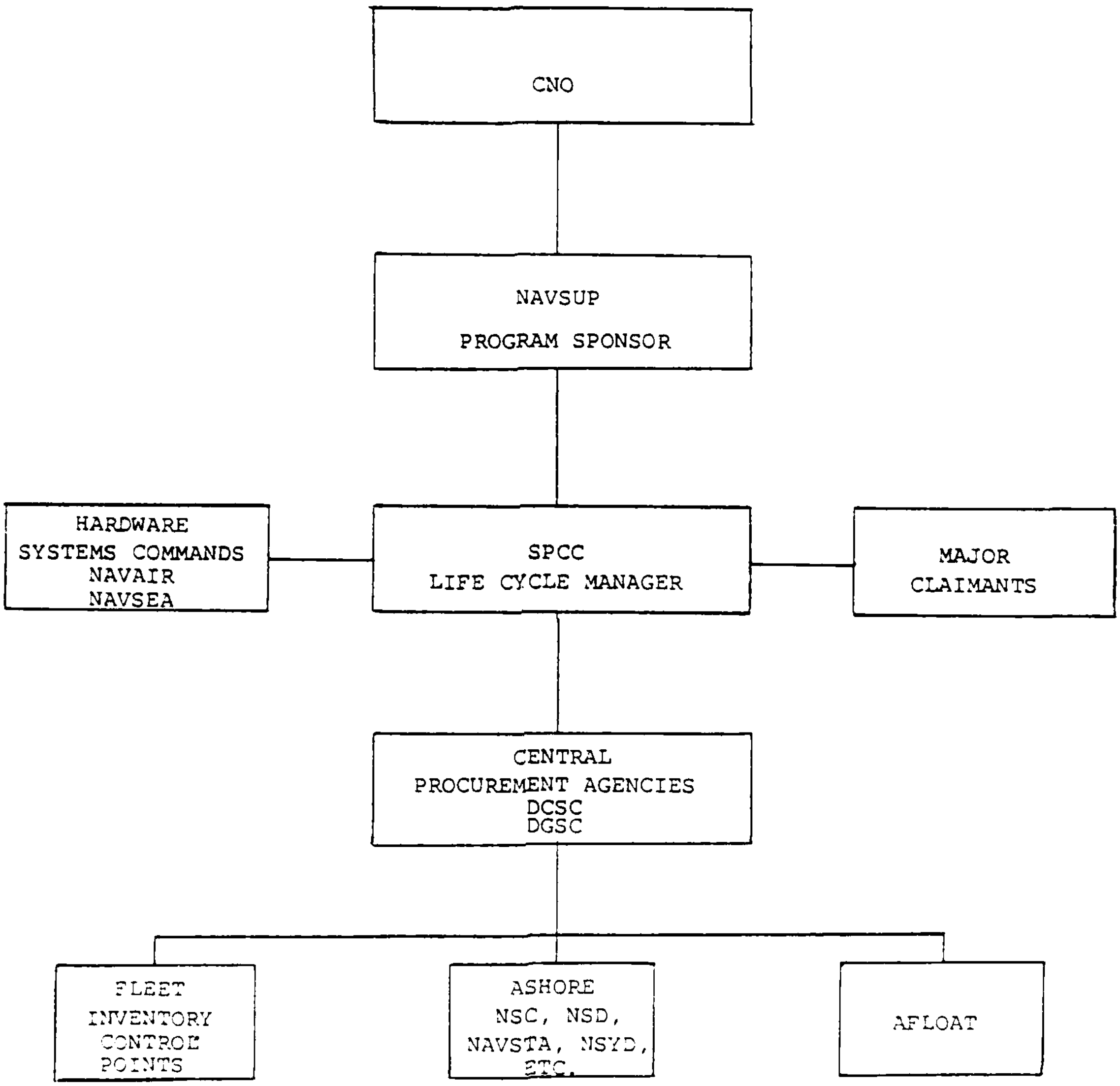

Figure 2.1 Management Structure for Navy MHE

services to utilize standard specifications when possible in order to achieve common administrative, technical, or logistic procedures and interchangeable supplies or equipment.

(E) Approve standards for MHE operator and maintenance training.

2. Hardware Systems Command (HSC)

The Naval Air Systems Command (NAVAIR) and Naval Sea Systems Command (NAVSEA) are the two Hardware Systems Commands (HSCs) that have an important role in MHE management. Essentially, they establish environmental requirements (i.e., nonsparking forks and bumpers on forklifts) for the handling of hazardous or explosive materials and develop or recommend design changes necessary to meet new mission requirements or to improve the material handling operation. The HSCs also advise SPCC of unique operational requirements desired by activities such as MHE used in cold storage or sand blast areas such as shipyards. Basically, the HSCs are a vital link between SPCC and the field activities with regard to identifying environmental and operational changes.

3. Major Claimant

To understand the major claimant's role in MHE management, it is first appropriate to describe what a major claimant is. The term "major claimant" is synonymous with the word "headquarters" and includes independent offices, commands and bureaus of the Navy such as Chief of Naval Education and Training (CNET), Commander in Chief, U.S. Pacific Fleet (CINCPACFLT) or Commander in Chief, U.S. Naval

Forces, Europe (CINCUSNAVEUR). The Chief of Naval Operations (CNO) issues Operation and Maintenance, Navy (O&MN) funds to the claimants who, in turn, issue operating budgets to field activities. The major claimants are responsible for the budgeting, accounting and reporting of these funds.

Regarding the management of MHE, major claimants have the responsibility to:

(A) Advise SPCC of any mission changes which may impact on MHE requirements.

(B) Endorse MHE allowance change requests for activities under their jurisdiction prior to sending them cn to SPCC.

(C) Budget and fund new mission or initial allowance requirements.

(D) Fund the maintenance and repair of MHE at cognizant using activities.

4. Defense Logistics Agency (DLA)

Two activities within DLA are heavily involved in the management of MHE. The Defense Construction Supply Center (DCSC) in Columbus, Ohio and the Defense General Supply Center (DGSC) in Richmond, Virginia, are the Central Procurement Agencies (CPAs) for all DOD for self-propelled MHE and nonpowered MHE, respectively. They receive MHE Requests for Contractual Procurement (RCP's) from all four military services since they are the sole authorized purchasers of MHE.

Because spare parts used to repair MHE are common to the services, DLA is also tasked with management of these parts. DCSC manages MHE spare parts using the Single Automated Material Management System (SAMMS) which is a DLA-wide inventory management system. SAMMS is a computer program application that calculates spare parts inventory levels based on demands (requisitions) received from the customer, distributes stock to needing activities, recommends when to buy and quantities to buy, computes quarterly demand and provides other common inventory management information. [Ref. 6]

5. Ships Parts Control Center (SPCC)

In 1973, NAVSUP designated SPCC as the Navy's life-cycle manager for MHE. As such, SPCC functions as the In-Service Engineering Agency (ISEA) and Program Manager/Inventory Control Point for all MHE owned and operated by Naval activities [Ref. 2:p. 1]. According to SPCC Instruction 10490.2, SPCC is charged with:

> . . . inventory management, requirements determination, procurement initiation, budgeting, asset distribution, administration and approval of allowances, rental/lease approval, establishment of utilization goals, specification development, engineering analysis, maintenance policy, disposal authority, and monitoring the overall performance of the MHE program. [Ref. 5:p. 2]

A more detailed description of SPCC management policies and procedures in provided in Sections C and D.

C. SPCC MANAGEMENT

Prior to April 1973, NAVSUP was responsible for the procurement, budgeting, and inventory management of MHE. Since that date, SPCC has performed those functions. The remaining technical and engineering functions were transferred from NAVSUP in July 1976. The present MHE office (Code 0302) at SPCC, consists of the following sixteen billets: a director, three program managers, three assistant program managers, five engineers, one equipment specialist and three supply clerks. This office reports directly to Code 03, the director of the Fleet/Industrial Support Group. Close cooperation between the program manager, engineer and equipment specialist (EES) is required to efficiently perform their assigned tasks. A description of the program manager, engineer and equipment specialist responsibilities is provided in the following subsections.

1. Engineer and Equipment Specialist (EES)

As mentioned earlier, SPCC, Code 0302, is the In-Service Engineering Agency (ISEA) for MHE. As such, it has three major functionsal responsibilities to perform. First, it is tasked with developing the equipment maintenance concept and the procedures to implement it. This includes assignment of a Source, Maintenance and Recoverability (SM&R) code. The SM&R code specifies the appropriate level of repair capability for a specific end item and prescribes the disposition action for unserviceable support items. Input from the manufacturer and application and design complexity of the item determine the SM&R code [Ref. 7:p. 2-22].

Developing and updating Lead Allowance Parts Lists (LAPL's) is another duty performed by the EES in developing the MHE maintenance concept. A LAPL is a complete listing of all maintenance significant repair parts that may be required to repair a specific unit of MHE. SPCC uses input provided from the manufacturer and the fleet to keep LAPL's current.

MHE procurement specifications are also developed and maintained by SPCC. This includes preparation of procurement technical packages which contain the Request for Contractual Procurement (RCP), funding document, delivery destination, transportation instructions and other pertinent data. SPCC also designs performance specifications for specialized MHE applications and environmental factors.

Finally, SPCC conducts technical reviews of first article tests, technical manuals, and Provisioning Technical Documentation (PTD). The inspection and testing of the first unit of MHE produced by a manufacturer, commonly known as first article testing, is required to assure that the manufacturer complies with specification requirements. A thorough review of technical manuals is also necessary to ensure complete operating and maintenance procedures (including service and overhaul information) and an illustrated parts list are provided. Lastly, PTD is reviewed for accuracy to ensure that Navy requirements for the equipment, such as range and depth of spares, repair parts and related support equipment, are properly conveyed to the manufacturer. Upon completion of PTD, the manufacturer provides DCSC with the initial spare parts requirements and the procurements are initiated.

2. Program Manager

SPCC's MHE program managers (Code 0302) are vital to the MHE program. They are basically responsible for the development and implementation of MHE program policy. A program manager is tasked with evaluating and approving or disapproving allowances, requirements determination, initiating procurements and acting as contract administrator, performing inventory control functions, analyzing and monitoring MHE utilization against goals and developing budget requirements.

D. CHANGES IN SPCC POLICIES AND PROCEDURES

As a result of the 1980 GAO report which criticized Navy management of MHE, SPCC initiated procedures to tighten management control and improve the productivity of MHE. Subsection two provides insight into these improvements. The other subsections discuss SPCC policies, still in effect, that have been strongly re-emphasized.

1. Management

MHE is centrally controlled by Code 0302 personnel at SPCC using U.S. Navy registration numbers (13-00000 series). National Stock Numbers (NSN's) are not used for

MHE. Each piece of MHE is assigned a unique number that will never be duplicated.

For the purposes of budgeting and procurement, MHE is grouped according to an equipment cost code which describes the type of MHE (i.e., forklift, tractor, crane, etc.), propulsion (i.e., gas, diesel, electric or liquified propane gas), and type of tires (pneumatic or solid). Appendix A provides a complete listing of these standard MHE cost codes [Ref. 5:Encl.6].

2. <u>Utilization</u>

According to SPCC Instruction 10490.2, "Equipment should be utilized to the maximum possible extent in order to recover the capital investment of the equipment" [Ref. 5:p. 3]. To monitor utilization, SPCC policy now requires that each unit of MHE have an hour-totalizing meter installed. Meter reading information provided by the user on the MHE ON-BOARD form is used by SPCC to compute the actual hours the equipment was used.

Utilization of each piece of MHE is calculated as the percentage ratio of actual hours of use divided by 2,000 available operating hours in a fiscal year (50 weeks at 40 hours per week) [Ref. 5:p. 3]. Utilization rates for newly acquired equipment, which has not been assigned to an activity for the entire reporting period, is calculated on the basis of 2,000 available hours pro rated by the number of months assigned to an activity.

It is essential that all hour meters be maintained in good operating condition since utilization has a direct impact on procurement decisions and an activity's allowance.

At the user level, SPCC's new policy states that a central point of control must be established for the purpose of pooling MHE to ensure the best possible utilization. By dispatching equipment from this pool to operations rather than assigning it full-time to individual activities where it may sit idle, costs can be kept to a minimum and operating efficiency at a maximum. Additional advantages to centralized control are that activity MHE requirements/allowance can be better determined and preventive maintenance scheduled more easily.

As was stated in Chapter I, low MHE utilization rates were highlighted in a GAO report dated 1980. As a result, SPCC initiated a five-year plan to establish minimum MHE utilization goals for various activities in order to adjust allowances, to eliminate excesses and to dispose of or redistribute excess equipment. Since the scope for this thesis is limited to Naval Supply Centers, a description of their five-year plan is provided in Table I.

The former utilization goal of 60% for MHE was impractical. This goal was based on the life expectancies listed in the DOD criteria in Appendix B. A utilization goal of 40% was chosen because that percentage is used at the DLA Supply Centers.

TABLE I

UTILIZATION GOALS FOR NAVAL SUPPLY CENTERS

TARGET UTILIZATION GOALS	CONUS	OVERSEAS*
By 30 Sep 1980	30%	25%
Yearly Increment	2%	2%
By 30 Sep 1985	40%	35%

*The overseas MHE utilization goal is lower due to non-availability of supply sources and commercial repair facilities. [Ref. 5:Encl.1].

These utilization goals were established to maximize effective application of MHE while considering the varied functions performed by NSC's. As these goals are attained the MHE inventory throughout the Navy should decrease.

3. Annual Report

The primary source of information that SPCC uses to make allowance, budgeting, procurement, and replacement decisions concerning MHE is the Annual Report. On or about 15 September of each year SPCC requires all activities with MHE to fill out an MHE ON-BOARD (UPDATE INFORMATION) form (SPCC-10490/2) (see Appendix C). These forms reflect the past fiscal year usage and inventory data. Other pertinent data includes downtime, material condition code, months on board, current hour meter reading and repair costs.

In addition, a computer listing of current authorized MHE inventory from SPCC files is forwarded to each activity for the purpose of comparing on-board equipment with authorized allowances. Current SPCC policy requires that MHE inventories match authorized allowances. SPCC requires that all excess equipment be reported as part of the Annual Report form on Standard Form 120 (see Appendix D). Delivery of new MHE will not be made to activities holding equipment in excess of the total authorized allowance. If equipment needs exceed the allowance, an allowance change request with complete justification must be submitted to SPCC (Code 0302) via the respective activity's major claimant.

Return of these forms to SPCC by 15 November is essential because the data contained on these forms are used in the preparation of MHE procurement budgets and in the determination of an individual activity's priority for the replacement of MHE.

4. Budgeting

Budgeting for MHE is divided between initial requirements and replenishment requirements. The respective major claimant is responsible for budgeting and funding all its activities initial MHE requirements to support new or increased mission responsibilities. These new allowance requirements are incorporated and prioritized by the major claimant into its total Program Objectives Memorandum (POM) requirements for a given year.

Replacement requirements for MHE in existing approved allowances are SPCC's responsibility. MHE budgeting responsibilities assigned to SPCC are for replacement of in-use MHE which have reached or exceeded their economic age. Therefore, the over-age position of the MHE fleet determines the Other Procurement, Navy (OPN) budget figure for future replacement of MHE. The MHE program goals established by NAVSUP and the Navy Comptroller are less than 20% over-aged MHE ashore and no over-aged MHE on board ship [Ref. 8].

To calculate the projected number of units of MHE to replace in a given year, while maintaining these goals, SPCC uses a Budget Simulation Model (BSM). Some of the more significant parameters used in the model include the current inventory, year of manufacture, current replacement costs, life spans, MHE due in and funds available in a given budget year. The model recommends buys for the projected oldest units of MHE in each category of equipment cost code. [Ref. 8:p. 1] The BSM enables SPCC to make sound and reasonable budgeting decisions for future years.

5. Replacement

MHE replacement decisions are made by SPCC based on Department of Defense (DOD) criteria (see Appendix B). These are incorporated in the BSM. According to this criterion, MHE is retired based on its age, condition, accumulated repair cost, as well as one-time repair costs relative to age and replacement cost of equipment. The replacement factors provide the program manager with explicit criteria to consistently determine the most economical time of replacement. First, past repair records are reviewed to determine if the equipment has required an unusual amount of maintenance. Secondly, MHE utilization is reviewed to ensure that the equipment is adequately used. Thirdly, the annual report provides information on equipment condition and their recommendation to replace or retain equipment. By comparing this information to the DOD criteria, the program manager at SPCC makes a rational and objective decision on which units of MHE should be replaced. [Ref. 9:p. 1]

Further discussion of the DOD MHE replacement philosophy is provided at the end of Chapter III. Then, in Chapter IV, a comparison is made between the economic life concept from the private sector and the DOD replacement concept for forklift trucks.

III. MAINTENANCE AND REPAIR

A. INTRODUCTION

The successful operation of material handling equipment is dependent upon proper periodic maintenance and quality repair work. The frequency of repairs required is directly related to the amount and type of usage as well as the quality of preventive maintenance services performed. The preventive maintenance system has been effective in prolonging the life of equipment, minimizing unscheduled service interruptions, minimizing replacement costs, and promoting the effective use of maintenance manpower.

The purpose of this chapter is to describe the Navy's preventive maintenance policies and procedures pertinent to the operation and handling of MHE used ashore at Naval Supply Centers. Also, repair cost estimates and limits are described since repair costs are a significant factor considered in the replacement of MHE. Finally, the chapter ends with a discussion of non-standardization and two approaches for determining when to replace a unit of MHE.

A brief definition of several terms is appropriate to gain a better understanding of the discussion to follow.

Preventive Maintenance--Preventive Maintenance is that maintenance which is the responsibility of and performed by a using organization on its assigned equipment. It consists of the inspection, servicing, surveillance, adjusting, and lubrication of equipment in order to minimize breakdown and keep equipment in good operating condition.

Corrective Maintenance (repair)--Corrective maintenance includes all maintenance required as a result of equipment or parts failure, to restore a unit of equipment back to operational condition.

Organizational Level Maintenance--Organizational maintenance is maintenance performed at the site where the user operates the equipment. It basically consists of users performing maintenance limited to visual inspections, external adjustments to equipment and periodic checks of equipment performance. This level does not remove and replace components or repair equipment but forwards it to the intermediate level.

Intermediate Level Maintenance--This level of maintenance is performed at a specialized shop located near the consumer. Equipments are repaired by the removal and replacement of major assemblies and piece parts. The basic responsibility of the intermediate level is to provide on-site maintenance to hasten the return of equipment to active status in an accelerated manner.

One-Time Repair Cost--One-time repair cost refers to the limit on the cost of corrective maintenance applicable to each complete repair job performed on an equipment. The intermediate level of maintenance determines the repair job estimate. If the estimate does not exceed the DOD criteria the repair is permitted. If the repair estimate exceeds the criteria the equipment should be replaced.

Accumulated Repair Cost Limit--The accumulated repair cost limit is the sum of all actual inspection and repair costs incurred during the entire life of the item. This includes the price of parts actually consumed in the repair process, the exchange charge for complete assemblies or subassemblies installed, and all direct and indirect labor involved. [Ref. 10:p. 1]

With reference to repair costs, both the one-time repair cost and the accumulated repair cost limit are values imposed as part of the DOD MHE replacement criteria.

B. MAINTENANCE CONCEPT AND PLAN

The maintenance concept as defined by Blanchard [Ref. 11:p. 104]

> . . . delineates maintenance support levels, repair policies, organizational responsibilities for maintenance, effectiveness measures (e.g., maintenance environment(s), and is a principal factor in determining logistic support requirements.

He further indicates that this concept has a three-fold purpose:

> (1) It provides the basis for the establishment of supportability requirements in system/equipment design. It also provides design criteria for major elements of logistic support (e.g., test and support equipment, large facility, etc.).
>
> (2) It provides the basis for the establishment of requirements for the total logistic support. The maintenance concept, supplemented by the logistic support

analysis, leads to the identification of maintenance tasks, task frequencies and times, personnel quantities and skill levels, test and support equipment, spare/repair parts, facilities, and other resources.

(3) It provides a basis for detailing the maintenance plan and impacts upon the supply concept, training concept, supplier/customer services, phased logistic support, transportation and handling criteria, and production data needs. [Ref. 11:pp. 104-105]

The current MHE maintenance concept requires that all operating equipment be maintained in a safe and serviceable condition in accordance with the Materials Handling Equipment Maintenance Manual, NAVSUP Publication 538, and the respective manufacturer's technical manual. The subsections that follow present a broad description of the specifications from NAVSUPUB 533.

1. Preventive Maintenance Scheduling

The preventive maintenance plan must be based on actual equipment operation as measured by an hour totalizing meter. A well planned program also needs a well trained maintenance staff. However, in order to carry out the preventive maintenance program in proper fashion sufficient management authority must be in place. The most significant part of a preventive maintenance scheduling program is the requirement for an accurate record keeping system in order to record repair requests and maintenance steps. This record must be kept up-to-date for each unit of equipment and must be periodically reviewed for general equipment condition and indications of repetitive failures in the same component.

It is more efficient to group equipment with similar utilization patterns by maintenance cycle. The maintenance cycle determines the scheduling frequency of preventive maintenance for each group. Table II displays the four basic preventive maintenance cycles and schedules. [Ref. 10:p. 27]

TABLE II

PREVENTIVE MAINTENANCE CYCLES AND SCHEDULES

PM CYCLE	DEFINITION	SCHEUDLE: EVERY
A	Equipment operating under adverse environmental conditions.	40 to 65 days or 100 to 260 hours
B	Equipment utilized over 100 hours per 65-day period	65 days or 260 hours
C	Equipment used less than 100 hours per 65-day period	130 days
D	Non-powered	90 days

2. Organizational Level Maintenance Responsibilities

The primary responsibility for preventive maintenance belongs to personnel at the organizational level of maintenance who operate material handling equipment. Daily, prior to placing the equipment in operation, the operator is responsible for:

a. Checking fuel, coolant, and crankcase oil levels.

b. Checking operation of lights, brakes, windshield wipers, gauges, horn, and hydraulic controls.

c. Checking tire pressure, condition of tires, and external condition of equipment.

d. Cleaning the outside of the radiator with compressed air if applicable.

e. Ensuring required safety equipment is on the equipment. This consists of a first aid kit and a fire extinguisher. [Ref. 10:p. 3]

In addition to these daily checks, the operator is responsible for ensuring that the equipment is never overloaded. By exceeding a truck's rated load capacity, added strain is placed on all component parts, maintenance increases, and the life of the equipment is shortened.

Before personnel can become qualified operators they must receive training in the safe and proper operation of MHE. DOD Instruction 4145.19R-1 outlines a course of on-the-job training, licensing and testing of personnel to become qualified operators of MHE. Some of the requirements included in this course are: vision, hearing and reaction tests; a physical examination; fundamental and advanced training in fork truck operation; and operating rules [Ref. 12:p. E-11]. The proper training of operators can contribute to minimizing the need for equipment maintenance and repair.

3. Intermediate Level Maintenance Responsibilities

The direct responsibility for preventive and corrective maintenance is assigned to personnel of the intermediate level maintenance shops. These shops are normally located in close proximity to normal MHE operations to afford timely repair and reduce downtime.

When MHE is brought into a shop for preventive maintenance service an inspector performs a thorough review of the equipment in accordance with the Preventive Maintenance Guide (NAVSUP From 1377, see Appendix E). The inspector uses this form to assign maintenance responsibility, provide a record of services performed, and indicate the specific areas that require servicing. By referring to past maintenance records and to NAVSUP Form 1377, preventive maintenance servicing can be limited to specific items. This procedure eliminates the overservicing that is common when maintenance history is not considered.

If, however, the inspection indicates major adjustments or corrective repairs, the inspector will prepare a Shop Repair Order (SRO) (NAVFAC 11200/3A, see Appendix F). This form outlines the required maintenance for the equipment, identifies the work center responsible, and lists the cost of labor and material.

An individual history jacket for each piece of MHE is maintained by the maintenance shop. The information contained in this jacket provides a complete history of the service life of the equipment. Information filed consists of the hours of operation, the costs of maintenance and materials, inspection data from NAVSUP Form 1377 and all Shop Repair Orders.

The maintenance shop also has the responsibility of maintaining the manufacturer's technical manuals. This consists of updating the manuals upon receipt of manufacturer's changes related to maintenance procedures or safety.

These manuals provide the manufacturer's recommended maintenance procedures, time schedules, lubrication schedules, principles of operation, trouble shooting guide, repair instructions and other useful maintenance data relative to the specific unit of MHE. The manuals also contain an illustrated parts breakdown of assemblies and a complete parts list.

4. Repair Time Standards

Repair time standards have been established which list the actual steps to be performed and the average times required to perform those steps. The time standards for the repair, overhaul, and preventive maintenance of MHE are to be utilized as management tools for the purpose of establishing a measurement and comparison of the time actually consumed on maintenance operations. This information assists in evaluating the effectiveness of first line supervision in monitoring repair work and it helps to measure the productivity of labor forces. Chapter 4 of NAVSUP Publication 538 contains the repair time standards for the more common units of MHE.

5. <u>Quality Deficiency Report (QDR)</u>

The Quality Deficiency Report (Standard Form 368) is used by all Naval activities for reporting unsatisfactory performance or failures attributable to faulty design or material in an equipment (see Appendix G). This report can also be used to report inadequacies in the MHE technical manual.

If a defective equipment is still under the manufacturer's warranty the local service representative should be notified to correct the deficiency. A standard warranty extends for a period of fifteen months from date of delivery. Latent defects, which may later become apparent by causing failure or nonusability of the item well within normal service life expectancy, are also covered under the warranty. In either case, a QDR should be submitted.

According to NAVSUP Publication 538, a QDR may be initiated for any of the following reasons:

a. The deficiency poses a threat to personnel or equipment.

b. The design of certain parts considered necessary for proper operation, maintenance, or handling of equipment is imperfect.

c. The deficiency is a result of excessive deterioration sooner than expected under normal operating conditions.

d. Defective material is the apparent cause of the deficiency.

When a deficiency occurs, a QDR is submitted to SPCC for technical review. SPCC then forwards the QDR to DCSC for investigation and resolution. The QDR provides SPCC with a feedback mechanism to highlight and identify MHE and technical manual deficiencies.

C. NON-STANDARDIZATION

Two problems that complicate maintenance of MHE are the usage of non-standard performance specifications in procuring a unit of MHE and the supply support the equipment receives during its lifetime.

1. Non-standardization

A common problem that exists today is the usage of the non-standard performance specification in the procurement of MHE. A performance specification is a document included in the Request for Contractual Procurement (RCP) that sets forth the criteria or standards of performance of a piece of MHE. It expresses criteria in terms of functions to be performed such as degrees of precision, speed of operation, capacity levels, environmental protection and quality standards. The degree of restriction in describing the function and performance is limited only by the inventiveness and imagination of the writer devising the specification [Ref. 13:p. 6]. In addition, each successive procurement can lead to another manufacturer and design resulting in further non-standardization. Finally, maintenance costs rise due to the inefficiency of requiring mechanics to be familiar with many different makes and models of MHE.

The forklift truck performance specification is a complex document. For example, military specification MIL-T-21868B for a shipboard diesel forklift truck refers to 27 other Federal/Military specifications and standards, 9 separate industry standards, 59 different combinations of tests and inspections, and extensive physical performance tests. [Ref. 13]

The difficulties associated with an over-specification such as this are extensive. First, the manufacturer must be capable of interpreting the intertwined and cross-referenced specifications. Second, he must possess or have access to testing facilities that include a 542 feet long track complete with obstacles; salt water fog equipment; and a hi-shock (vibration) testing capability.

2. <u>Supply Support</u>

The Navy's MHE inventory includes approximately 66 types of equipment and 87 different manufacturers. Because of this non-standardization, repair parts support becomes increasingly difficult. Each time a different manufacturer receives a contract for MHE, a new Allowance Parts List (APL) must be produced for that buy of MHE. In turn, provisioning for the range and depth of spare parts must be accomplished for each APL. This is a time consuming process that involves screening manufacturer's part numbers and descriptions to determine if a National Stock Number (NSN) already exists for those items. When an NSN does not exist, one is assigned.

This entire process, from APL initiation to spare parts being available at a stock point, averages between one to three years. Therefore, new equipment received by an activity could be down for a long time before the spare parts are available in the supply system.

Requisitioning parts through the Navy supply system is also time consuming, causing downtime to increase. Fortunately, an activity can use the open purchase method to obtain spare parts from the local manufacturer of that equipment. With great emphasis being placed on the achievement of MHE utilization goals [Ref. 2:p. 3], the activity's top priority is to reduce downtime as much as possible. Therefore, open purchase has become the rule rather than the exception. Because such spare parts are available within one or two days, downtime is reduced dramatically. Unfortunately, open purchasing has a negative impact in two ways; first, it places a heavy paperwork load on an activity's supply department; and second, the supply system is deprived of demand being recorded against the DLA managed items, resulting in these spare parts inventory levels being reduced.

Older units of MHE also experience a distinct lack of supply support. As the numbers of old equipment decrease, recorded demand for their respective spare parts decreases dramatically. Thus, parts may not be on the shelf to fill requisitions. Even if the manufacturer is still in business, the part is probably obsolete due to upgraded or changed design of the equipment. The part must then be fabricated, which is very costly and time consuming.

D. REPAIR COSTS AND REPLACEMENT

The repair costs are important for determining when to replace DOD MHE. The accumulated repair cost and the one-time repair cost are used together with other criteria to determine the most economical time of replacement.

The following subsections explain the methodology for making repair cost estimates. They also provide a description of the DOD methodology used in making MHE repair or replacement decisions.

1. Repair Cost Estimates

Prior to performing major corrective repairs on a unit of MHE (i.e., engine overhaul), a repair cost estimate must be considered to determine if it is more economical to repair or to actually replace the equipment. DOD instruction 7220.21 prescribes the uniform procedures for obtaining repair cost estimates. Four elements of cost are used in estimating the repair cost: direct labor, direct material, indirect expenses and other direct charges. Direct labor and direct material are that labor and material that is specifically applied and identified to the repair job performed. The indirect costs include administrative costs and the manufacturing or production expense incurred that can be identified to the maintenance shop. "Other direct charges" include contractual services, preparation for shipment, and freight (if shipped overseas). [Ref. 14:p. 6]

It is important to note that such items as tires, batteries, tire chains, and antifreeze are not to be included in the repair cost estimate except where replacement is the result of accident damage.

2. <u>Repair Cost Limits</u>

As stated in Chapter II, the replacement of MHE is governed by the DOD constraints contained in Appendix B. These are designed to avoid excessive expenditures for the repair of MHE. The decision to replace or repair equipment is basically straightforward using these limits. However, other factors should also be considered.

When a unit of MHE requires repairs which exceed the DOD constraints for one-time, or accumulated repair costs, no further repair expenditure is permitted, and the item will usually be retired from operational use. However, retirement will not be effected if:

a. The required repairs exceed the maximum cumulative cost limit, but will extend the life of the equipment for a period comparable with the expenditure required. This decision is made at the individual activity level. SPCC closely monitors equipment that meet this criterion.

b. The item is beyond the maximum utilization years and any one-time repair cost does not exceed 10% of the current replacement cost. In addition, the maximum cumulative limit must not be exceeded. [Ref. 10:p. 8]

This procedure can best be demonstrated and understood with an example. Suppose a 4000 pounds capacity, gasoline powered forklift truck with pneumatic tires, manufactured in 1983 needs repairs costing an estimated $6,200. Appendix H lists the current replacement cost of this type of MHE as $12,500. According to the DOD criteria in Appendix B, the maximum allowable one-time repair cost limit is 40% of current replacement cost or $5,000. Thus, the equipment should be replaced unless one of the two exceptions listed above can be applied.

E. ECONOMIC LIFE OF MHE AND REPLACEMENT

In the private sector the determination of the economic life of a unit of MHE is used in deciding upon the most cost effective and, therefore, most advantageous time for replacement of that unit. According to Chester [Ref. 15:p. 90], the "economic life" of MHE is the point at which it has attained its maximum use for the least cost. Maximum use is defined as that point in the life of the equipment when utilization of the equipment is consistently high. This is usually much shorter than the "useful life" which he describes as somewhere in the 10 to 15 year range, depending on the kind of maintenance, the amount of usage and the environmental working conditions experienced.

Tracking the economic life of a piece of MHE requires the determination of two cost components: maintenance and ownership. Typically, as operating hours accumulate, maintenance costs rise while ownership costs fall. In this discussion, the ownership cost is the difference between the purchase price of the equipment and its salvage value when traded in. For example, assume a unit that cost $12,000 new and operates for 8,000 engine hours over five years. The industry standard trade-in value of 20% is subtracted from the original price to determine the ownership cost of $9,600 or $1.20 per engine hour.

The cumulative maintenance cost is the total of maintenance labor and material cost from the date of delivery. Suppose, for this example, that the total is $7,000. Dividing by the engine hours results in a total maintenance cost per engine hour of $.87. The total cost per cumulative engine hour is therefore $2.07.

Andrew [Ref. 16:p. 2] states that the lowest total cumulative cost per engine hour is the time for MHE replacement. Figure 3.1 shows the curves of ownership and maintenance costs as a function of engine operating hours for the example. It also shows their total. The value of $2.07 precedes the equipment's lowest cumulative cost per engine hour and replacement is therefore unnecessary. The optimal replacement time is that point where the maintenance and ownership hourly costs are equal; approximately 9600 hours.

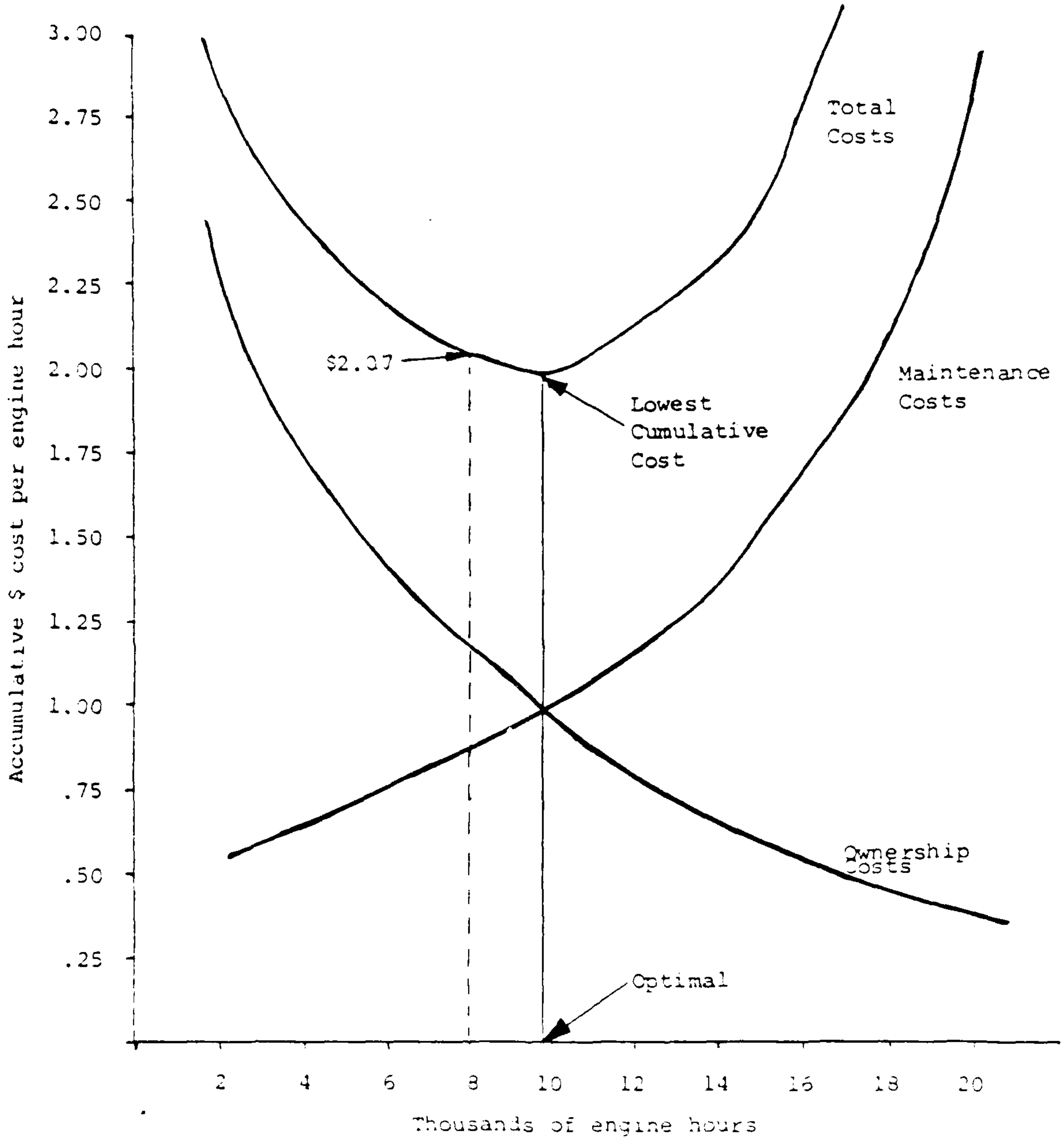

Figure 3.1 Optimal Operating Point of MHE

IV. THE CURRENT STATUS OF NAVY FORKLIFT TRUCKS

In order to develop recommendations to improve and maintain a high quality MHE fleet, an analysis was conducted by the author to ascertain the current state of MHE. The size of the Navy's MHE inventory and the lack of available time limited the scope of this analysis to the Navy's eight Naval Supply Centers. The scope of the statistical analysis was further limited to forklift trucks, since forklift trucks are considered to be the logistic workhorses of the Navy. Forklifts comprise over 75% of the total MHE fleet and approximately 80% of the NSC fleet. Finally, as was stated in Chapter I, the data used in this analysis was acquired from the fiscal year 1985 Ashore Activity Verification and Allowance Listing Report produced by SPCC.

This chapter will present and discuss the results of the statistical analysis. It will also address compliance with DOD replacement criteria, the achievement of utilization goals and the current status of the NSC forklift fleet with regard to economic life. The statistical analysis is limited to comparing the sample average values.

A. AVERAGE AGE

As was stated in Chapter II, the projected over-age position of the MHE fleet helps to determine the amount of funds budgeted for the procurement of new equipment. The age of MHE, therefore, is an important factor in managing an equipment replacement program.

An overall view of forklift age at all Naval shore activities is provided in Table III. This table is a snapshot of the age distribution of forklift trucks on hand, by year of manufacturer, as of 30 June, 1986 [Ref. 17:p. 3]. Based on NAVSUP's definition, MHE is over-age when it "is beyond the maximum utilization years of economical use as shown in" Appendix B [Ref. 10:p. 9]. It can be seen that 33% of the forklifts with a life span of both eight and ten years are over-aged. 24% of the forklifts having an age life of fifteen years are over-aged.

TABLE III

FORKLIFT AGE DISTRIBUTION

	1971 & prior	1972	1973	1974	1975	1976	1977	1978
# of trucks (8 yr life)	363	47	48	8	139	50	127	156*
# of trucks (10 yr life)	104	0	19	1	27	11*	36	74
# of trucks (15 yr life)	401*	11	85	13	37	34	114	113

	1979	1980	1981	1982	1983	1984	1985	1986
# of trucks (8 yr life)	221	522	145	227	258	322	135	105
# of trucks (10 yr life)	1	27	50	12	41	69	13	2
# of trucks (15 yr life)	106	78	164	139	127	149	133	1

*Over-age trucks include this year and all prior years.

It is significant to note that almost half of these over-aged forklifts are sixteen years old and older.

These figures greatly exceed the NAVSUP goal of 20% over-aged MHE ashore. Based on the 743 additional forklifts in the eight year life category that will become over-age in two years, it is likely that the over-age position of this category of forklifts will be degraded even more.

Table IV shows the average age of forklift trucks and the percentage of over-age forklift trucks at each of the eight NSC's. The eight NSC's are: Naval Supply Center Puget Sound (NSCPS), Naval Supply Center Pensacola (NSCP), Naval Supply Center Jacksonville (NSCJ), Naval Supply Center Pearl Harbor (NSCPH), Naval Supply Center Charleston (NSCC), Naval Supply Center San Diego (NSCSD), Naval Supply Center Oakland (NSCO), and Naval Supply Center Norfolk (NSCN). The typical forklift in the total NSC inventory averages 7.2 years. NSCJ and NSCSD are the only two Supply Centers meeting NAVSUP's goal of less than 20% over-age equipment ashore.

Once an equipment reaches or exceeds its expected life span, SPCC considers it over-aged. The life spans for various types of forklifts and other MHE are contained in Appendix B.

These over-age equipments are not cost effective to maintain for continued operation because repair parts are probably obsolete or difficult and costly to obtain.

TABLE IV

AVERAGE AND OVER-AGE OF FORKLIFTS

	# Trucks on hand	Average Age (in years)	# Trucks over-age	% Trucks over-age
NSCPS	51	7.4	13	25.5
NSCP	60	8.9	18	30.0
NSCJ	83	5.7	11	13.3
NSCPH	91	7.8	29	31.9
NSCC	110	7.2	24	21.8
NSCSD	186	6.3	27	14.5
NSCO	321	6.9	74	23.1
NSCN	630	7.6	151	24.0

Replacement of over-aged equipment with new and more efficient models would reduce excessive costs attributable to repair, preventive maintenance and downtime. However, replacement of over-age equipment cannot apparently occur in sufficient numbers because of procurement funding constraints and an activity's own recommendation not to replace.

As an SPCC assistant program manager observed, a forklift that is over-age and qualifies for replacement is sometimes retained by an activity because its maintenance costs and downtime are low. Although this is in keeping with the DOD criteria, it raises the over-age percentage of the MHE population.

In addition, the mechanic is very familiar with the maintenance history of the equipment which helps to reduce maintenance costs and downtime. The replacement of the forklift with a new version would require the mechanics to spend time learning how to maintain the new one.

B. FUNDING FOR PROCUREMENT

Table V displays the ashore over-age status and the funds budgeted for procurement of new MHE for those respective years. Funding increased dramatically for fiscal year 1981 and the following years. This caused the over-age percentage of forklifts to drop accordingly.

TABLE V

FORKLIFT FUNDING AND POPULATION OVER-AGED

FISCAL YEAR	BUDGETED $ (millions)	OVER-AGE %
1977	15.9	48
1978	14.5	45
1979	18.7	43
1980	17.5	40
1981	23.6	37
1982	20.6	38
1983	24.0	30
1984	25.7	26
1985	23.0	23
1986	8.6	36*
1987	9.5	39*
1988	19.8*	34*
1989	15.8*	37*
1990	15.6*	41*
1991	15.6*	47*
1992	14.6*	48*

*Projected

Figure 4.1 plots the data in Table V. It appears that an increase or decrease in funds has a direct impact, although not linearly or even consistently, on the percentage of over-age forklift Navy-wide. Based on reduced projected funding figures, the future percentages of over-age forklifts ashore can be expected to climb dramatically.

C. DOD REPLACEMENT CRITERIA COMPLIANCE

Chapters II and III discussed the methodology used by DOD to economically replace equipment. This section examines the repair costs, downtime, and accumulated repair costs of MHE located at the Navy's eight NSCs in an attempt to identify the extent of compliance with the DOD replacement criteria.

1. Average Repair Cost

The average cost of repairing forklift trucks in FY 1985, per Supply Center, is illustrated in Table VI.

TABLE VI

FY 85 AVERAGE FORKLIFT REPAIR COST

	# trucks on hand	Total Repair Cost	Average Repair Cost
NSCPS	51	$43,047	$844
NSCP	60	36,854	614
NSCJ	83	84,450	1,018
NSCPH	91	157,286	1,728
NSCC	110	152,467	1,386
NSCSD	186	85,422	459
NSCO	321	462,099	1,440
NSCN	630	1,070,540	1,699

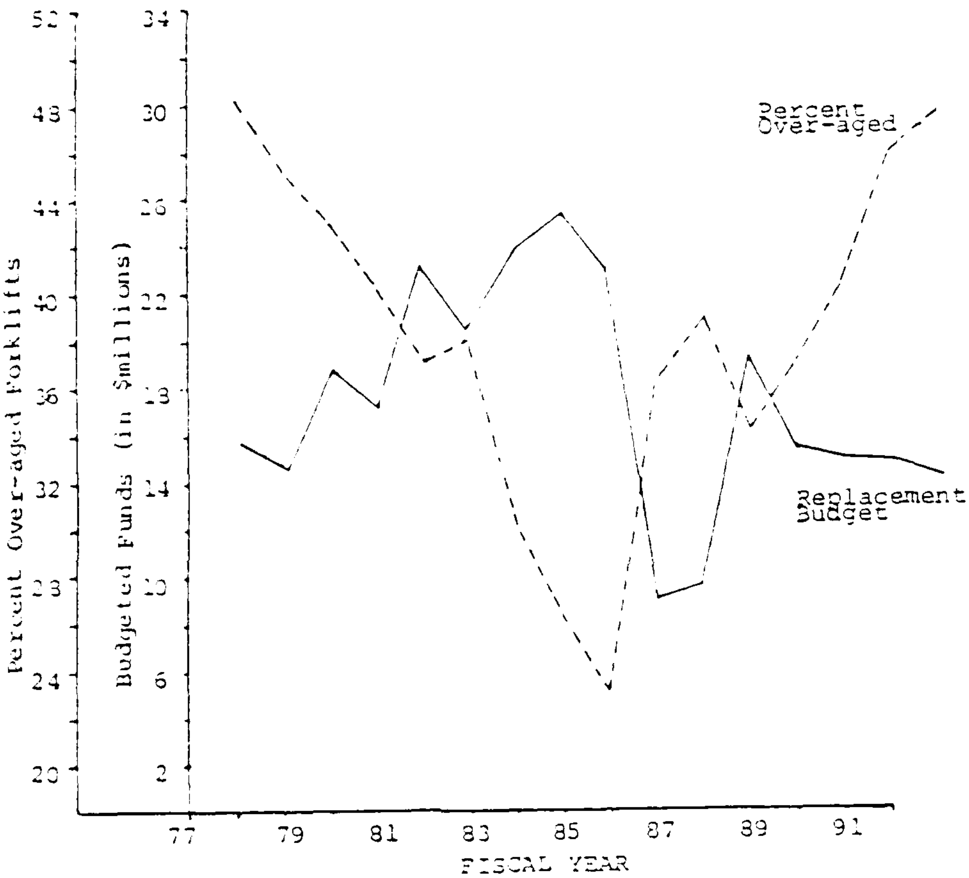

Figure 4.1 Actual and Projected Forklift Funding and Over-aged Percentage as a Function of Fiscal Year

Average repair costs range from a high repair cost of $1728 per truck at NSC Pearl Harbor to an extremely low $459 per truck at NSC San Diego.

The average cost will vary per NSC depending on several factors such as: the number and age of forklift trucks, the quality of the preventive maintenance program, the knowledge and skill level of operators and mechanics, and whether the repair work is done at the organizational or intermediate level. During a research trip, the author noted that MHE maintenance at NSC San Diego is performed at the organizational level with the exception of one-time major overhauls which are performed at the intermediate level (Public Works Center). In contrast, intermediate level maintenance is performed by the Public Works Center (PWC) for all of NSC Oakland's MHE. Although NSCSD has 42% less forklift trucks than NSCO, a quick comparison suggests that organizational maintenance is more cost efficient than intermediate maintenance.

It is significant to point out that five out of the eight Naval Supply Centers use PWC as the intermediate level of maintenance for MHE. Of the remaining three, NSCSD and NSCPH use the organizational level of maintenance and NSCJ recently contracted-out maintenance to a commercial firm.

2. <u>Average Accumulated Repair Cost</u>

Table VII lists the average forklift accumulated repair cost for fiscal year 1985. The total repair cost is the summation of lifetime repair costs for the number of forklifts present. Dividing this value by the number of trucks on hand gives the average accumulated repair cost per truck.

TABLE VII

FY 85 AVERAGE FORKLIFT ACCUMULATED REPAIR COST

	# trucks on hand	Total Accum. Repair Cost	Avg. Accum. Repair Cost
NSCPS	51	$207,436	$4,067
NSCP	60	201,751	3,363
NSCJ	83	362,536	4,368
NSCPH	91	614,360	6,751
NSCC	110	738,085	6,710
NSCSD	186	492,752	2,649
NSCO	321	1,922,961	5,991
NSCN	630	4,242,660	6,734

Once again, NSCSD has the lowest repair cost per truck. Comparing the NSC over-age percentage in Table IV with the accumulated repair cost in Table VII, there appears to be a direct correlation between NSCSD's low over-age percentage and low repair cost per truck. The correlation also exists between NSCPH's high over-age percentage and high accumulated repair cost.

3. Average Downtime

The average downtime per forklift, for fiscal year 1985, is presented in Table VIII. Downtime hours refer to the total hours the equipment was not operating due to being repaired or while waiting for required repair parts. In the opinion of maintenance personnel interviewed at NSCSD and NSCO, waiting for repair parts was the dominant factor of the downtime figure.

As shown in Table VIII, the average forklift downtime per Supply Center ranges in value from 20 hours per truck at NSC Pensacola to 289 hours per truck at NSC Jacksonville. This is noteworthy considering the fact that NSCJ has the lowest average age of forklifts. Because of the large difference in average downtime between NSCP and NSCJ, the cause of this difference should be examined for possible application in reducing overall downtime at all NSC's.

TABLE VIII

FY 85 AVERAGE FORKLIFT DOWNTIME

	# Trucks on hand	Downtime (in hours)	Avg. downtime (in hours)
NSCPS	51	7,557	148
NSCP	60	1,670	28
NSCJ	83	23,999	289
NSCPH	91	15,023	165
NSCC	110	19,248	175
NSCSD	186	17,010	91
NSCO	321	65,358	204
NSCN	630	139,742	222

4. <u>DOD Criteria Compliance</u>

The basic intention of the DOD criteria for MHE replacement is to prevent maintenance funds from being expended on uneconomical or over-age equipment. In order to demonstrate compliance with the DOD criteria, it is appropriate to combine repair costs, accumulated repair costs and downtime figures onto one graph, Figure 4.2. This figure illustrates that, as a whole, the Naval Supply Centers do comply with this criterion because each curve flattens out. As the age of MHE increases, the dollar value of maintenance associated with that equipment increases but at a decreasing rate. This implies that over-age equipment is being replaced before maintenance costs increase dramatically.

Additionally, the longer MHE is operated, the greater the probability of parts failure and inability to acquire replacement parts. This leads to increased repair costs and downtime. Because such increases are not evident in Figure 4.2, it also implies that MHE is replaced in accordance with the DOD criteria.

D. UTILIZATION GOALS

The five-year plan established by SPCC for increasing utilization was presented in Chapter II. This plan set the MHE utilization goals for Naval Supply Centers at 40% in CONUS and 35% overseas. These goals were to be achieved by the end of fiscal year 1985. Table IX lists the utilization rates for all MHE as of 30 September, 1985, per Supply Center. Forklift utilization rates are also presented to demonstrate their importance in determining a Supply Center's overall utilization rate. The utilization rate was

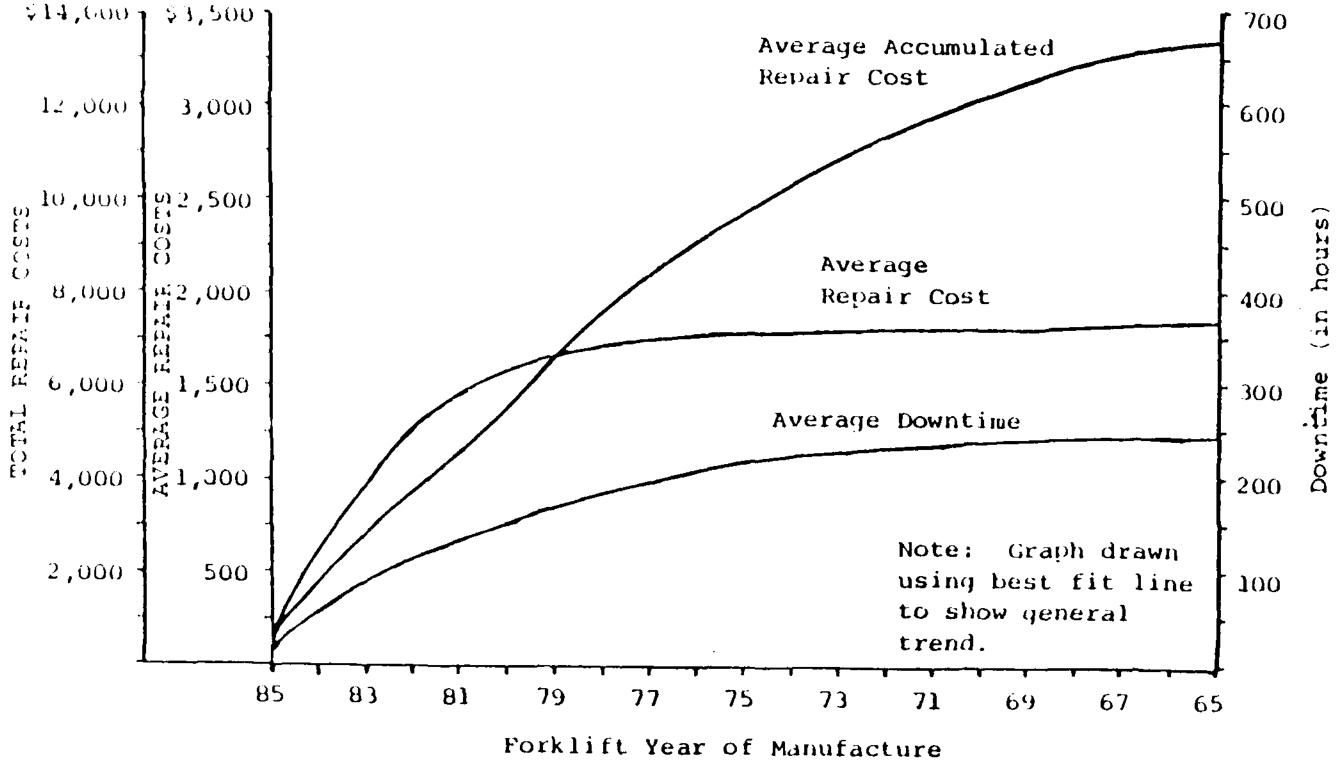

Figure 4.2 DOD Replacement Criteria Compliance

determined by summing the accumulated hours of operation and dividing by the hours available in a year (2000) for each unit of equipment.

TABLE IX

FY 85 MHE VERSUS FORKLIFT UTILIZATION

	# MHE on hand	% Utilized	# Trucks on hand	% Utilized
NSCPS	62	38	51	40.7
NSCP	63	27	60	31.1
NSCJ	93	31	83	30.7
NSCPH	106	27	91	30.0
NSCC	134	36	110	32.1
NSCSD	213	33	186	34.0
NSCO	405	23	321	23.5
NSCN	829	22	630	29.0

As is shown, none of the NSC's achieve the Navy's goal of 40% utilization, although NSCPS and NSC Charleston (NSCC) were close at 38% and 36%, respectively.

An interview with the MHE Maintenance Branch Foreman at NSCSD indicated one possible factor that contributes to low utilization. That factor is the replacement of the hour totalizing meter. Hour totalizing meters are replaced, on the average, every two to three years depending on utilization. When an hour meter is replaced, the old meter reading is frequently not recorded. At the end of the fiscal year, the reading on the new meter is recorded in SPCC's Annual Report. Thus, utilization for that year drops.

Another cause of low utilization is that some forklifts cannot be supported on a utilization basis due to isolated operating locations and unique mission requirements [Ref. 18:p. 5]. However, the requirement to handle material at a remote location must still be satisfied.

The physical layouts of various activities prohibit the pooling of MHE. For example, at NSCSD, there are four separate locations all of which require forklifts to perform their missions. These locations are geographically separated by approximately five or more miles from each other which makes the pooling of forklifts impractical.

Table X lists the actual utilization of specific units of several types of forklift trucks in the current NSC inventory which have reached or exceeded their expected age in years. The years of expected usage column lists the number of years the associated equipment was expected to operate in accordance with SPCC Instruction 10490.2. The "expected total hours of usage" column is calculated by multiplying the expected number of years by the available hours in a year (2000). The result is then multiplied by the 40% utilization goal for Supply Centers to arrive at the total number of hours the unit of MHE is expected to operate in its life. The four examples were selected to demonstrate the "worst case" under-utilization of MHE.

The inefficient utilization of MHE is shared by all the NSC's. Table XI lists data concerning the numbers of

TABLE X

EXPECTED UTILIZATION VERSUS ACTUAL UTILIZATION

Equipment	EXPECTED USAGE Years	EXPECTED USAGE Total hours	ACTUAL USAGE Years	ACTUAL USAGE Total hours	ACTUAL USAGE Expected use
Forklift, gas, 6,000 lbs.	8	6,400	11	2,533	40%
Forklift, gas, 15,000 lbs.	8	6,400	11	1,804	28%
Forklift, elec. 15,000 lbs.	15	12,000	16	4,501	38%
Forklift, diesel, 15,000 lbs.	10	8,000	10	3,118	39%

over-age equipment which have not provided the hours of useful service anticipated when they were purchased. These figures were calculated in the same manner as those in Table X.

TABLE XI

INEFFICIENT UTILIZATION

	# Trucks over-age	# Over-aged trucks not providing anticipated hours of service	% Over-aged trucks not providing anticipated hours of service
NSCPS	13	7	53.8
NSCP	18	8	44.4
NSCJ	11	11	100.0
NSCPH	29	17	58.6
NSCC	24	22	91.7
NSCSD	27	21	77.8
NSCO	74	27	36.9
NSCN	151	122	80.8

The combined totals of all eight NSC's reveals the magnitude of this utilization inefficiency. Of the 347 over-age equipments in the current inventory, 235 units of MHE or 67.7% have qualified for replacement based on age but have not operated the expected hours. It can be inferred that over-age forklifts result in increased downtime and hence lower utilization.

E. ECONOMIC LIFE ANALYSIS

Identifying the economic life of MHE is crucial to its productivity and replacement. Continued repair and overhaul of an equipment appears on the surface to be a reasonable method of extending MHE service life. It must be realized, however, that the longer the equipment is used, the greater the downtime and maintenance costs. Increasing maintenance costs will ultimately result in an equipment's economic obsolescence.

Chapter III discussed the private sector's view of the economic life of MHE as being the point in time at which maintenance costs equal ownership costs. The data in Tables XII and XIII are presented to show the status of forklifts based on this economic life concept.

Table XII is a list of four economically obsolete forklifts from the FY 1985 NSC inventory. The ownership cost per hour were derived by dividing the acquisition cost by the accumulated engine hours and assumes no scrap value. To determine the maintenance cost per hour, the total accumulated maintenance costs were divided by the accumulated engine hours.

TABLE XII

ECONOMICALLY OBSOLETE FORKLIFTS

Equipment	Age	Accum. eng. hrs.	Purchase cost	Ownership cost/hr	Maint. cost	Maint. cost/hr
Forklift, electric	15	8141	$6,596	$ .81	$13,561	$1.67
Forklift, gas	14	3543	7,081	1.99	12,260	3.46
Forklift, LPG	21	11,439	3,855	.34	15,485	1.35
Forklift, gas	8	3193	8,650	2.71	11,864	3.72

These forklifts are economically obsolete because maintenance costs per hour are higher than ownership costs per hour. Under the private sector's concept of economic life, these forklifts should have been replaced long ago.

Table XIII shows the percentage of the total NSC forklift population that are economically obsolete using the private sector's definition. The average age of these trucks is also presented. The values range from 5% obsolete at NSCSD to a high of 31% obsolete at NSCC. In the aggregate, 353 or 23% of the total Supply Center forklift fleet is economically obsolete.

The DOD replacement criteria also appears to provide an economic life model. However, the basic difference between

TABLE XIII

FY 85 ECONOMICALLY OBSOLETE FORKLIFT DATA

	# Trucks on hand	# Trucks obsolete	% Trucks obsolete	Average age (in years)
NSCPS	51	8	16	17.5
NSCP	60	10	17	19.8
NSCJ	83	8	10	16.4
NSCPH	91	26	29	15.5
NSCC	110	34	31	12.6
NSCSD	186	10	5	13.3
NSCO	321	84	26	12.8
NSCN	630	173	27	13.4

the DOD and the private sector replacement philosophy is the ownership cost. As discussed in Chapter III ownership cost is the difference between the purchase price of the equipment and its salvage value. For this discussion salvage value is zero. When making MHE replacement decisions, the private sector uses the original purchase price whereas DOD uses the current replacement cost of the equipment.

Because replacement costs usually increase every year, use of the current replacement cost, by DOD, increases the cumulative repair cost limit. Therefore, total accumulated repair costs can increase over the years and still remain within the maximum cumulative repair limit. This eventually leads to replacement of the equipment at an older age than would be obtained from the private sector model.

The private sector ownership cost remains constant over the years, therefore, replacement would occur at an earlier age.

V. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

A. SUMMARY

Reliable and readily available MHE is vital to all large scale military supply, maintenance and transportation operations. Therefore, the need to improve the quality of the Navy's MHE fleet cannot be over-emphasized.

This thesis has presented an in-depth review of the Navy's current management policies, maintenance, concept and plan, and replacement methodology for the present MHE fleet. It has also analyzed the current status of Navy forklifts at CONUS Naval Supply Centers to determine the average age and over-age of MHE, the compliance with DOD MHE replacement criteria, utilization rates and the extent of economically obsolete MHE. The results of this analysis showed that a significant percentage of forklift trucks are over-aged and economically obsolete.

The findings of this thesis indicate the seriousness of the current state of MHE. The proposed solutions are designed to increase utilization in an attempt to attain prescribed goals and also, to reduce repair costs and downtime.

B. CONCLUSIONS

Several conclusions have been reached as a result of reviewing the current methods and policies of maintaining the Navy's fleet of MHE.

First, the Navy's forklift truck fleet is unusually old and its state suggests that the rest of the MHE is also. The advanced age of this fleet directly contributes to the high cost of maintenance and repair parts, increased downtime and low utilization.

Second, the current SPCC material handling equipment utilization goals are attainable. However, they cannot be realized if central control and pooling is not well-established, if allowances are allowed to be excessive, and if economically obsolete equipment is not disposed of in a timely fashion.

Third, the Department of Defense MHE replacement methodology is inappropriate for determining the proper time to replace equipment because, although it appears the criteria are complied with, a significant percentage of the forklift fleet is still over-aged and economically obsolete.

Fourth, the usage of the complicated performance specifications for the procurement of MHE results in many differently designed pieces of equipment. This causes non-standardization of the Navy's MHE inventory which leads to problems of repair and spare parts support.

C. RECOMMENDATIONS

In light of the conclusions reached above, the recommendations in the following paragraphs are made to further reinforce the results of this study.

The DOD replacement criterion is over 30 years old and is inadequate for determining the most economical time to replace material handling equipment. It is recommended that a study be conducted to develop a computer program that could be used to determine the economic life of an equipment based on the private sector replacement concept. The program must be capable of generating useful information for decision making such as: monthly and cumulative costs per engine hour; the projected cost per engine hour of a replacement equipment; the annual savings if the equipment were replaced at that time; and finally, percent return on investment.

In order to lower MHE expenditures, it is proposed that standardization of the more common types of forklift trucks be effected. This could be implemented by procurement of commercial, off-the-shelf equipment. The Navy could take advantage of lower costs accruing from high volume production. By significantly reducing the number of MHE manufacturers, cost-efficiency and productivity would receive a boost because service and supply support would increase. Additionally, downtime would decrease and maintenance efficiency would improve because the mechanic previously forced to work on all makes can now become master of a few. Before taking this initiative, however, a thorough cost/benefit analysis must be conducted to ensure adequate industry support.

A review of the current overall MHE maintenance concept and plan should be conducted to determine the most cost-efficient and effective method of repairing MHE at Naval Supply Centers. This should include a study of Public Works Center operations, contracting repairs out commercially, and the organizational level of maintenance.

The format of the Annual Report presently in use is adequate for documenting the information required by SPCC to determine an activity's utilization and which specific equipments to replace. However, the time lag caused by the massive manual input of data at SPCC, late submissions from activities, and the general frequency of the report results in the Verification and Allowance Listing Report to be slightly outdated. It is recommended that the frequency of the report be changed to quarterly in order to obtain more current information to make sound decisions. Because of the large volume of feedback reports received, however, the success of implementing this change depends on the automation of the feedback report itself.

In addition to the manual input mentioned above, records are manually maintained at the majority of activities. It is proposed that simplification of data collection, calculation and reporting be accomplished through computerization.

This would reduce required labor resources and redirect these resources to be utilized more efficiently in other tasks.

This report has considered only forklifts at Naval Supply Centers. The study of forklifts should next be extended to that on board ships. The high tempo of shipboard operations, the exposure to a corrosive environment, and the rapid turnover of both qualified operators and mechanics create difficulties such as increased downtime and non-accomplishment of scheduled preventive maintenance.

APPENDIX A

EQUIPMENT COST CODES AND DESCRIPTIONS FOR MHE

Equip. Cost Code	Equip. Group Code	Description	Cost Acct. Maint.	Cost Acct. Oper.
1100	R	Tractor, warehouse, up to and including 4,000 pounds DBP, pneumatic tire, gas	64R0	65R0
1110	R	Tractor, warehouse, over 4,000 pounds DBP, pneumatic tire, gas	64R0	65R0
1120	R	Tractor, warehouse, 2,000 to 4,000 pounds DBP, solid tire, electric	64R0	65R0
1200	R	Crane, truck, warehouse and industrial, pneumatic tire, gas	64R0	65R0
1210	R	Crane, truck, warehouse and industrial, solid tire, gas	64R0	65R0
1220	R	Crane, truck, warehouse and industrial, solid tire, electric	64R0	65R0
1230	R	Crane, truck, magazine, solid tire, electric, spark enclosed	64R0	65R0
1240	R	Crane, gas-electric, all capacities, SRT	64R0	65R0
1300	R	Truck, forklift, up to and including 6,000 pounds, pneumatic tire, gas	64R0	65R0
1305	R	Truck, forklift, up to and including 6,000 pounds, penumatic tires, LPG	64R0	65R0
1310	R	Truck, forklift, over 6,000 pounds, pneumatic tire, gas	64R0	65R0
1320	R	Truck, forklift, all capacities, solid tire, gas	64R0	65R0
1325	R	Truck, forklift, all capacities, solid tire, LPG	64R0	65R0
1330	R	Truck, forklift, up to and including 6,000 pounds, pneumatic tire, diesel	64R0	65R0
1340	R	Truck, forklift, over 6,000 pounds, pneumatic tire, diesel	64R0	65R0
1350	R	Truck, forklift, all capacities, solid tire, diesel	64R0	65R0
1360	R	Truck, forklift, all capacities, solid tire, electric	64R0	65R0
1370	R	Truck, forklift, all capacities, solid tire, electric, spark enclosed	64R0	65R0
1375	R	Truck, forklift, all capacities, penumatic tires, electric, spark enclosed	64R0	65R0
1380	R	Truck, forklift, all capacities, solid tire, electric, explosion proof	64R0	65R0
1390	R	Truck, forklift, tiering, straddle, and reach-type, electric	64R0	65R0
1395	R	Truck, forklift, all capacities, stockpicking, electric	64R0	65R0
1400	R	Truck, fixed platform, pneumatic tire, gas	64R0	65R0
1410	R	Truck, fixed platform, pneumatic tire, electric	64R0	65R0
1420	R	Truck, elevating platform, solid tire, electric	64R0	65R0
1430	R	Truck, elevating platform, pneumatic tire, gas	64R0	65R0
1440	R	Truck, fixed platform, pneumatic tire, diesel	64R0	65R0
1500	R	Truck, straddle-carry, up to and including 60,000 pounds, gas or diesel	64R0	65R0
1600	R	Truck, lift, hand, pallet-type, all capacities, electric	64R0	65R0
1610	R	Truck, lift, hand, pallet-type, all capacities, electric, spark enclosed	64R0	65R0
1800	R	Truck, forklift, rough terrain, all capacities, pneumatic tire, gas	64R0	65R0
1810	R	Truck, forklift, rough terrain, all capacities, crawler, gas	64R0	65R0
1820	R	Truck, forklift, rough terrain, all capacities, pneumatic tire, diesel	64R0	65R0
1830	R	Truck, forklift, rough terrain, all capacities, crawler, diesel	64R0	65R0
1840	R	Truck, side-loader, up to and including 10,000 pounds, gas	64R0	65R0
1850	R	Truck, side-loader, over 10,000 pounds, gas	64R0	65R0
1860	R	Truck, side-loader, up to and including 10,000 pounds, diesel	64R0	65R0
1870	R	Truck, side-loader, over 10,000 pounds, diesel	64R0	65R0
1880	R	Truck, side-loader, all capacities, electric	64R0	65R0
1900	Z	Miscellaneous materials-handling equipment including trailers, handtrucks, handcarts, and pallet-type handlift trucks	6440	6540

APPENDIX B

REPAIR LIMITS & LIFE EXPECTANCIES FOR MHE (SHOREBASED)

REPAIR LIMITS & LIFE EXPECTANCIES FOR MHE (SHOREBASED)

Type of Equipment	Maximum Economical Utilization		Maximum Cumulative Repair Limit % of Replacement Cost*	Maximum Allowable "One Time Repair Limits" % of Replacement Costs — Hours in Use (In Hundreds)														
	Yrs.	Hrs.		12	24	36	48	60	72	84	96	108	120	132	144	156	168	180
Fork Truck, Gas/Diesel, 2000# to 6000#	8	9,600	100	50	45	40	35	25	20	15	10	-	-	-	-	-	-	-
Fork Truck, Gas/Diesel, 7500# to 15,000#	10	12,000	100	50	45	40	35	30	25	20	15	10	10	-	-	-	-	-
Tractor, Gas/Diesel	8	9,600	100	50	45	40	35	25	20	15	10	-	-	-	-	-	-	-
Crane, Gas/Diesel	12	14,400	100	50	50	45	45	40	40	35	30	25	20	15	10	-	-	-
Platform Truck, Gas/Diesel	8	9,600	100	50	45	40	35	25	20	15	10	-	-	-	-	-	-	-
Truck, Straddle/carry, Gas/Diesel	15	18,000	100	50	50	50	45	45	45	40	40	35	35	30	25	20	15	10
Fork Truck, Electric, 2000# to 6000#	15	18,000	100	50	50	50	45	45	45	40	40	35	35	30	25	20	15	10
Tractor, Electric	15	18,000	100	50	50	50	45	45	45	40	40	35	35	30	25	20	15	10
Crane, Electric	15	18,000	100	50	50	50	45	45	45	40	40	35	35	30	25	20	15	10
Platform Truck, Electric	15	18,000	100	50	50	50	45	45	45	40	40	35	35	30	25	20	15	10
Pallet Truck, Electric	15	18,000	100	50	50	50	45	45	45	40	40	35	35	30	25	20	15	10

APPENDIX C

MHE ON-BOARD (UPDATE INFORMATION) FORM

ANNUAL REPORT | PAGE | REPORT SYMBOL 4400-21

UIC

NOTE TO USER OF THIS FORM

1 Zeros fill all data fields

2 Slash all zeros

3 MTH ON BRD (months on board). Show actual number of months assigned to your activity during past fiscal year. Maximum that can be shown is 12.

4 Round off meter readings, down time, and hours used to nearest whole number. (Do not use tenths.)

5 Round off repair costs past year and accumulated to nearest whole dollar. (Do not include cents.)

6 Fill in activity name and UIC.

3 COND CODE	4 REPAIR COSTS PAST YEAR	5 REPAIR COSTS CUMULATED	6 DOWN TIME PAST YEAR	7 HOURS USED PAST YEAR	8 MTH ON BRD	9 CURRENT METER READING

APPENDIX D

REPORT OF EXCESS PERSONAL PROPERTY

PAGE 1 OF ____

STANDARD FORM 120 REV.
APRIL 1957
GEN. SERV. ADMIN.
FPMR (41 CFR) 101-43.311

REPORT OF EXCESS PERSONAL PROPERTY

1. REPORT NO.
2. DATE MAILED
3. TOTAL COST $

4. TYPE OF REPORT — Check one only of "a," "b," "c," or "d" — a. ORIGINAL — b. CORRECTED — c. PARTIAL W/D — d. TOTAL W/D — Also check "e" and/or "f" if appropriate — e. OVERSEAS — f. CONTRACTORS INV

5. TO (Name and Address of Agency to which report is made) THRU

6. APPROP. OR FUND TO BE REIMBURSED (if any)

7. FROM (Name and Address of Reporting Agency)

8. REPORT APPROVED BY (Name and Title)

9. FOR FURTHER INFORMATION CONTACT (Title, Address and Telephone No.)

10. AGENCY APPROVAL (if applicable)

11. SEND PURCHASE ORDERS OR DISPOSAL INSTRUCTIONS TO (Title, Address and Telephone No.)

12. GSA CONTROL NO.

13. FSC GROUP NO.

14. LOCATION OF PROPERTY (If location is to be abandoned give date)

15. REIM. REQD — YES — NO

16. AGENCY CONTROL NO.

17. SURPLUS RELEASE DATE

18. EXCESS PROPERTY LIST

ITEM NO. (a)	DESCRIPTION (b)	COND. (c)	UNIT (d)	NUMBER OF UNITS (e)	ACQUISITION COST PER UNIT (f)	ACQUISITION COST TOTAL (g)	FAIR VALUE % (h)

STANDARD FORM 120 REV. APRIL 1957 EDITION — Use Standard Form 120A for Continuation Sheets. NSN 7540-00-634-4074 — PREVIOUS EDITION USABLE

APPENDIX E

PREVENTIVE MAINTENANCE GUIDE

PREVENTIVE MAINTENANCE GUIDE
NAVSUP FORM 1177 (2-81)

REGISTRATION NO	TYPE OF EQUIPMENT	HR METER READING	JOB ORDER NO	DATE

LUBRICATION†	SCHEDULED	PERFORMED
1 ENGINE OIL DRAIN AND REFILL (FLUSH*)		
2 LUBRICATE (Use available chart)		
3 TRANSMISSION (FLUSH*)		
4 DIFFERENTIAL (FLUSH*)		
5 CARBURETOR AIR CLEANER REMOVE CLEAN OIL		
6 OIL FILLER PIPE CAP REMOVE CLEAN OIL		
7 CRANKCASE BREATHER REMOVE CLEAN OIL		
8 BATTERY CHECK WATER LEVEL CLEAN TERMINALS		
9 CHAINS OIL		
10 RADIATOR CHECK WATER LEVEL (ANTIFREEZE*) (FLUSH*)		
11 HYDRAULIC RESERVOIRS CHECK ADD FLUID (FLUSH*)		

SIGNATURE | DATE

OPERATIONAL INSPECTION†	SCHEDULED	PERFORMED
1 INSTRUMENTS AND SWITCHES		
2 BRAKES SERVICE AND PARKING		
3 INCHING CONTROL		
4 CLUTCH FREE PLAY SLIPPAGE		
5 STEERING RESPONSE EFFORT		
6 TRANSMISSION SPEED RANGES AND CONTROLS		
7 HYDRAULIC CONTROLS LIFT SPEED & RETENTION OF ELEVATED RATED LOAD		
8 SAFETY HORN LIGHTS OVERHEAD GUARD FIRE EXTINGUISHER		

SIGNATURE AND DATE

INSPECTION AND SERVICING†	SCHEDULED	PERFORMED
1 VEE BELTS INSPECT ADJUST		
2 SPARK PLUGS CLEAN ADJUST TEST		
3 FUEL PUMP BOWL AND FILTER CLEAN		
4 WIRING INSPECT FOR BREAKS AND ATTACHMENTS		
5 GENERATOR BRUSHES COMMUTATOR (FLUSH*)		
6 STARTER BRUSHES COMMUTATOR (CLEAN*)		
7 DISTRIBUTOR (INSPECT*)		
8 CARBURETOR ADJUST (CLEAN*)		
9 GOVERNOR INSPECT AND ADJUST (Use tachometer)		
10 EXHAUST SYSTEM*		
11 LIFT CHAINS AND FORKS SHOES ADJUST (WASH*)		
12 HYDRAULIC CYLINDERS PACKING ATTACHMENTS		
13 MAST AND CARRIAGE ROLLERS MAST ATTACHMENT		
14 STEER LINKAGE		
15 TIRES		
16 CONTROLLER		
17 CONTRACTORS		
18 RESISTORS*		
19 ELECTRIC MOTORS BRUSHES COMMUTATOR MOUNTING		
20 WHEEL BEARINGS (REPACK*)		
21 THERMAL CUT OUT SWITCHES		
22 GENERAL INSPECTION AND TIGHTENING (HEAD MANIFOLD SUSPENSION)*		

†Use 'Remarks' space for any comments. If more space is needed, use the reverse side, indicating the section to which comments apply

SIGNATURE AND DATE

REMARKS (Lubrication)

REMARKS (Operational Inspection)

REMARKS (Inspection and Servicing)

APPENDIX F

SHOP REPAIR ORDER

NAVFAC 11200/3A (REV. 1-73)
SUPERSEDES NAVDOCKS 1948
S/N 0105-LF-004-1001

SHOP REPAIR ORDER PAGE OF

(1) SAO NUMBER
(2) JOB ORDER NUMBER
USN NUMBER
(3) EQUIPMENT DESCRIPTION
(4) MAKE
(5) MODEL
(6) YEAR
(7) EQUIP CODE
(8) DOD ALPHA
(9) ACTIVITY
(10) PHONE NUMBER
(11) LAST A TYPE PM
(12) LAST B TYPE PM
(13) LAST C TYPE PM
(14) ACCU MILES/HRS

TO BE COMPLETED UPON EQUIPMENT AVAILABILITY FOR MAINTENANCE REPAIR

PM GROUP (15)
PM TYPE DUE (16)
PM DATE DUE (17)
(18) DOWNTIME
IN DATE TIME
OUT DATE TIME
TOTAL HOURS
(19) PRESENT METER READING

(20) WORK GENERATION (Check applicable box)
[ ] 1 SCHEDULED [ ] 2 INTERIM [ ] 3 BREAKDOWN [ ] 4 ACCIDENT

(21) SCHED FOR REPLACE (Approx No Months)
[ ] 3 [ ] 6 [ ] 12

(22) WORK PERFORMANCE
[ ] 1 OWN ACT EQUIP [ ] 2 CUST EQUIP

(23) REPAIRED BY
[ ] 1 OTHER GOVT/SHOP [ ] 2 COMM CONT

MATERIAL RECORD

(24) QTY
(25) DESCRIPTION
(26) MFG PART NO
(27) AMOUNT
(28) WORK CTR
(29) CCC
(30) MAN HRS STD ACT
(31) WORK DESCRIPTION
(32) MECH INIT

LUBE CHASSIS (SERVICE AIR CLEANER AND BATTERY) [1]
CHANGE MOTOR OIL AND FILTER CARTRIDGE [2]
REPLACE BATTERY (CLEAN TERMINAL AND BOX) [3]
ADJUST BRAKES [4]

(33) PARTS ON ORDER (Reqn Numbers)
(34) TOTAL MATERIAL $
(35) TOT LABOR HRS

(36) WORK AUTHORIZED (Inspector's Signature) DATE
(37) WORK APPROVED (Supervisor's Signature) DATE

(38) CONTRACTUAL SERVICE REQUEST (Receipt of above order and equipment is hereby acknowledged. Permission to exceed work specified above *MUST BE AUTHORIZED* by requesting activity)

CONTRACTING FIRM
SIGNATURE DATE

FOR CUSTOMER JOB ESTIMATING
(39) LABOR (MAINT) HRS = $
(40) LABOR (OPER) HRS = $
(41) MATERIAL $
(42) OTHER $
(43) TOTAL COST $

APPENDIX G

QUALITY DEFICIENCY REPORT

Carbon paper not required to complete this side.

FRONT

QUALITY DEFICIENCY REPORT
(Category II)

SECTION I

1a. From (Originating point) | 2a. To (Screening point)

1b. Typed Name, Duty Phone and Signature | 2b. Typed Name, Duty Phone and Signature

3. Report Control No. | 4. Date Deficiency Discovered | 5. National Stock No. (NSN) | 6. Nomenclature

7. Manufacturer/Mfg. Code/Shipper | 8. Mfg. Part No. | 9. Serial/Lot/Batch No. | 10. Contract/PO/Document No.

11. Item ☐ New ☐ Repaired/Overhauled | 12. Date Manufactured/Repaired/Overhauled | 13. Operating Time at Failure | 14. Government Furnished Material ☐ Yes ☐ No

15. Quantity | a. Received | b. Inspected | c. Deficient | d. In Stock

16. Deficient Item Works On/With | a. End Item (Aircraft, tank, ship, howitzer, etc.) | (1) Type/Model/Series | (2) Serial No.
| b. Next Higher Assembly | (1) National Stock No. (NSN) | (2) Nomenclature | (3) Part No. | (4) Serial No./Lot No.

17. Dollar Value | 18. Est. Correction Cost | 19. Item Under Warranty ☐ Yes ☐ No ☐ Unknown | 20. Work Unit Code/EIC (Navy and Air Force only)

21. Action/Disposition
☐ Holding Exhibit for _____ days ☐ Released for investigation ☐ Returned to Stock/Disposed of ☐ Repaired ☐ Other (Explain in item 22)

22. Details (Describe, to best ability, what is wrong, how and why, circumstances prior to difficulty, description of difficulty, cause, action taken including disposition, recommendations. Identify with related item number. Include and list supporting documents. Continue on separate sheet if necessary.)

SECTION II

23a. To (Action Point) | 24a. To (Support Point) (Use items 25 and 26 if more than one)

23b. Typed Name, Duty Phone and Signature | 24b. Typed Name, Duty Phone and Signature

25a. To (Support Point) | 25a. To (Support Point)

25b. Typed Name, Duty Phone and Signature | 25b. Typed Name, Duty Phone and Signature

368-101

STANDARD FORM 368, April 1974
General Services Administration (FPMR 101-26.7)

APPENDIX G (CONTINUED)

BACK

Carbon paper is required – only face of form is chemical treated

SECTION III

27a. From *(Action point)*	28a. To *(Screening point)*
27b. Typed Name, Duty Phone and Signature	28b. Typed Name, Duty Phone and Signature
29. Specification No.	30. Originator's Method of Notification: ☐ SF 368 ☐ Msg *(Copy attached)* ☐ Phone Call/Visit

31. Type of Shipment/Purchase

Direct Delivery From Vendor:

☐ Depot ☐ Stock Item ☐ Nonstock Item ☐ Federal Supply Schedule ☐ Other *(Specify)*

32. Findings and Recommendations of Investigation. *(Explain in detail. Continue on a separate sheet of paper, if necessary.)*

33. Action Taken

34. Results of Depot Surveillance

35. From *(Screening point)*	36. To *(Originator)*

37. Distribution

APPENDIX H

1986 STANDARD FORKLIFT REPLACEMENT COSTS

DESCRIPTION	EQUIPMENT COST CODE	CAPACITY	TECHNICAL DATA	UNIT COSTS
Forklift, Gas, Pneumatic	1300	2000	127" Lift	$11,500
Forklift, Gas, Pneumatic	1300	4000	144" Lift	$12,500
Forklift, Gas, Pneumatic	1300	6000	180" Lift	$17,000
Forklift, LPG, Pneumatic	1305	2000	127" Lift	$12,000
Forklift, LPG, Pneumatic	1305	4000	144" Lift	$13,000
Forklift, LPG, Pneumatic	1305	6000	180" Lift	$17,500
Forklift, Gas, Solid	1320	2000	127" Lift	$12,000
Forklift, Gas, Solid	1320	4000	144" Lift	$12,000
Forklift, Gas, Solid	1320	6000	180" Lift	$19,000
Forklift, LPG, Solid	1325	2000	127" Lift	$12,500
Forklift, LPG, Solid	1325	4000	144" Lift	$12,500
Forklift, LPG, Solid	1325	6000	180" Lift	$18,000
Forklift, Diesel, Pneumatic	1330	2000	127" Lift	$14,500
Forklift, Diesel, Pneumatic	1330	4000	144" Lift	$14,500
Forklift, Diesel, Pneumatic	1330	6000	180" Lift	$13,000
Forklift, Diesel, Pneumatic	1340	8000	180" Lift	$34,000
Forklift, Diesel, Pneumatic	1340	10,000	168" Lift	$36,000
Forklift, Diesel, Pneumatic	1340	15,000	210" Lift	$37,000
Forklift, Diesel, Pneumatic	1340	20,000	210" Lift	$56,000
Forklift, Diesel, Solid	1350	2000	127" Lift	$14,500
Forklift, Diesel, Solid	1350	4000	144" Lift	$14,500
Forklift, Diesel, Solid	1350	6000	180" Lift	$18,000
Forklift, Electric, Solid	1370	2000	127" Lift	$16,500
Forklift, Electric, Solid	1370	4000	144" Lift	$20,500
Forklift, Electric, Solid	1370	6000	180" Lift	$25,000
Forklift, Electric, Solid	1370	8000	180" Lift	$32,000
Forklift, Electric, Pneumatic	1375	2000	127" Lift	$19,000
Forklift, Electric, Pneumatic	1375	4000	144" Lift	$22,000
Forklift, Electric, Pneumatic	1375	6000	180" Lift	$27,000
Forklift, Electric, Pneumatic	1375	8000	180" Lift	$34,000
Forklift, Electric, Solid EX *	1380	6000	144" Lift	$38,500
Forklift, Electric, Solid, R&T **	1390	3000	180" Lift	$22,000
Forklift, Electric, Solid, R&T	1390	4000	180" Lift	$27,000
Forklift, Electric, Solid, SP #	1395	2500	---	$20,000

* Explosion proof

**Reach-type

\# Stockpicking

LIST OF REFERENCES

1. U.S. General Accounting Office Report, Navy Material Handling Equipment Costs Can Be Reduced, 30 January 1980.

2. Naval Supply Systems Command Instruction 10490.33A, Administration and Control of Material Handling Equipment, 5 August 1985.

3. Personal interview with Mr. Tony Detoma, Assistant Program Manager, Navy Ships Parts Control Center, Mechanicsburg, Pennsylvania, 29 May 1986.

4. Personal interview with Mr. George Fruhworth, Code 0302, Navy Ships Parts Control Center, Mechanicsburg, Pennsylvania, 25 August 1986.

5. Navy Ships Parts Control Center Instruction 10490.2, Administration and Control of Materials Handling Equipment (MHE) for Naval Shore Establishments and Land-Based Operating Forces, 26 August 1981.

6. Telephone interview with Mr. Norm Hobson, Supervisor Inventory Manager, Defense Construction Supply Center, Columbus, Ohio, 27 October 1986.

7. Naval Supply Systems Command Publication 553, Inventory Management, 1981.

8. Personal interview with Mr. Jim Holtzinger, Program Manager, Navy Ships Parts Control Center, Mechanicsburg, Pennsylvania, 6 June 1986.

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